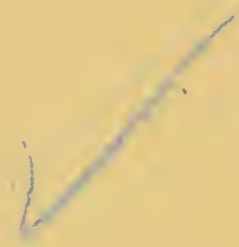


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*Sir David Dickson  
for his friend  
Astley Cooper*

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SOME  
EXPERIMENTS AND OBSERVATIONS  
ON TYING THE CAROTID  
AND  
VERTEBRAL ARTERIES,  
AND THE  
PNEUMO-GASTRIC, PHRENIC, & SYMPATHETIC NERVES.  
BY SIR ASTLEY COOPER, BART.

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THE anastomosis of arteries in all parts of the animal frame, and the circuitous channels through which the blood, when arrested in its progress along a principal trunk, is conveyed to its destination, have been for some time well ascertained; and the advantages arising from this arrangement of vessels in the natural condition of the body, as well as the safety afforded by it under certain accidents, diseases, and operations, are perfectly understood.

The existence of these anastomosing vessels has been proved, by the examination of diseases in which blood-vessels have been obliterated, by experiments performed upon the arteries of living animals, and by the result of surgical operations upon the human subject, and the dissections after death; and the injected preparations contained in our anatomical museums exhibit, for the principal arteries of the body, the place at which the main trunk has been rendered impervious, and the mode in which the circulation has been preserved.

In the chest, the aorta has been obliterated by disease, and the intercostal arteries have supplied its place in carrying on the blood. In the abdomen, the aorta has been entirely obstructed by an aneurism situated above the bifurcation; the two iliaes below being reduced to mere cords. The common iliac has been successfully tied by Mr. Guthrie; and the internal iliac by Mr. Stevens. The external iliac, and the arteries below it, have been now so frequently tied, and the

anastomosing vessels so clearly demonstrated, that no doubt is entertained of an adequate supply of blood being sent to the lower limbs after these operations.

The subclavian arteries have but few anastomoses; but they are still sufficient to nourish the upper extremity; and the arteries of the arm below may be tied without danger of an insufficient supply by subsidiary currents.

The carotid arteries have been found, by Baillie, obliterated by disease. That artery has been now frequently tied on one side of the neck; and it has even been secured, at distinct periods, on both sides of the neck of the same person: and in these cases, the current of the blood has still flowed freely into the remote branches.

Still, however, the intimate connection between the functions immediately essential to life—of the brain and other organs, and the necessity for a due supply of blood for the maintenance of cerebral action, gives to the vessels of the head extreme importance in the eyes of the surgeon and physiologist, and justifies him in pushing his inquiries respecting them to the utmost limit.

It will be seen that some animals die immediately from interrupting the circulation in the carotid and vertebral arteries; but that others survive the experiment, and give an opportunity of ascertaining the means of anastomosis.

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LIGATURES PLACED UPON THE VERTEBRAL AND CAROTID ARTERIES  
OF A DOG.

On the 28th of January, 1831, I tied the right and left vertebral and the right and left carotid arteries of a dog, and all was completed within half an hour. The animal appeared insensible, or as if it were intoxicated; it had difficulty in breathing; its pupils were dilated; its volition was diminished; and it ran against the leg of the table, or any other body, without seeing or regarding it. When placed upon its legs, it fell down on its right side, and had spasmodic twitchings of its hinder extremities.

At the expiration of a quarter of an hour, it was still insensible: it had shiverings, although placed near the fire: it rested its head upon the ground on the right side: its respiration was still laborious; and its pupils were dilated.

After an hour and a half, however, it was able to stand, and, although with difficulty, to stagger around a small room.

On the 29th, it was dull, and indisposed to move. On the 30th, it was much the same, and not inclined to move or eat. On the 31st, it walked round the room; and ate about an ounce of food, but would not lap. On the 1st of February, it was much better: it ate and drank; and from that time gradually recovered. It afterwards became a good house-dog; and I kept it for nine months, when it was killed, that I might inject it. The number and the size of the anastomoses were very extraordinary; and they are accurately exhibited in the accompanying Plates.\*

The description of them is as follows: The carotid artery on the right side was obliterated opposite the fifth and sixth cervical vertebræ: below the obliteration it is injected from the aorta; above the obliterated part it is filled with injection, (1) from the inferior thyroideal artery communicating with the superior thyroideal by large branches; (2) by a large descending cervical branch, dividing into numerous large anastomoses; and (3) by branches from the vertebral artery anastomosing with the external carotid artery on the first vertebra of the neck.

The left carotid was obliterated from near its origin, but filled with injection above the obliterated part, by the inferior thyroideal artery communicating with the superior, and by the ascending cervical artery from the subclavian, by numerous and large anastomoses, and by an œsophageal artery from one of the intercostals communicating with the superior thyroideal artery.

The right vertebral artery was obliterated near its origin on the seventh cervical vertebra, but filled with injection above the obliterated part by two branches from the superior intercostal arteries, which passed, on the back of the spine, into the arterial canal of the vertebræ, at the fourth, fifth, and sixth intercostal spaces. The vertebral artery thus produced passed to the second vertebra of the neck, where it formed the basilar artery, and, in its course, had festoons or loops formed in it, as far as the first vertebra, at each intervertebral substance;

\* The preparations are now in my possession.



## 6 *Sir A. Cooper on Tying the Carotid and Vertebral Arteries.*

and here, upon the transverse process of the first cervical vertebra, it formed communications with the carotid.

The left vertebral artery was obliterated close to its origin; but was filled with injection by an anastomosing branch from the superior intercostal artery, which entered between the fifth and sixth vertebræ of the neck; and by a second branch, also, from the intercostal artery passing on the posterior surface of the transverse processes of the fourth and fifth cervical vertebræ: then, over each transverse process was a loop of arterial communication, forming down each side a beautiful display of festoons.

The basillary artery began at the base of the second cervical vertebra; passed to the junction of the first vertebra to the head, where it again received vessels from the vertebral arteries; and then proceeded, as a single artery, to the points of the petrous portions of the temporal bones; where it formed the commencement of the circle of Willis, which was well filled with injection, and sent off its usual arteries to the brain.

The vertebral artery also joined the internal carotid artery on the transverse process of the second cervical vertebra of the neck.

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### PLATE, *Fig. 1.*

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FRONT VIEW OF A PREPARATION OF THE NECK AND HEAD OF A DOG IN WHICH THE CAROTID AND VERTEBRAL ARTERIES HAD BEEN TIED.

A. B. Obliterated Carotid Arteries.

c. Obliterated Vertebral Artery on the right side.—The left not seen in the drawing. The principal anastomosing arteries are, the ascending cervical on the outer side of the neck, and the superior and inferior thyroideal artery on the side of the trachea.





Fig. 1

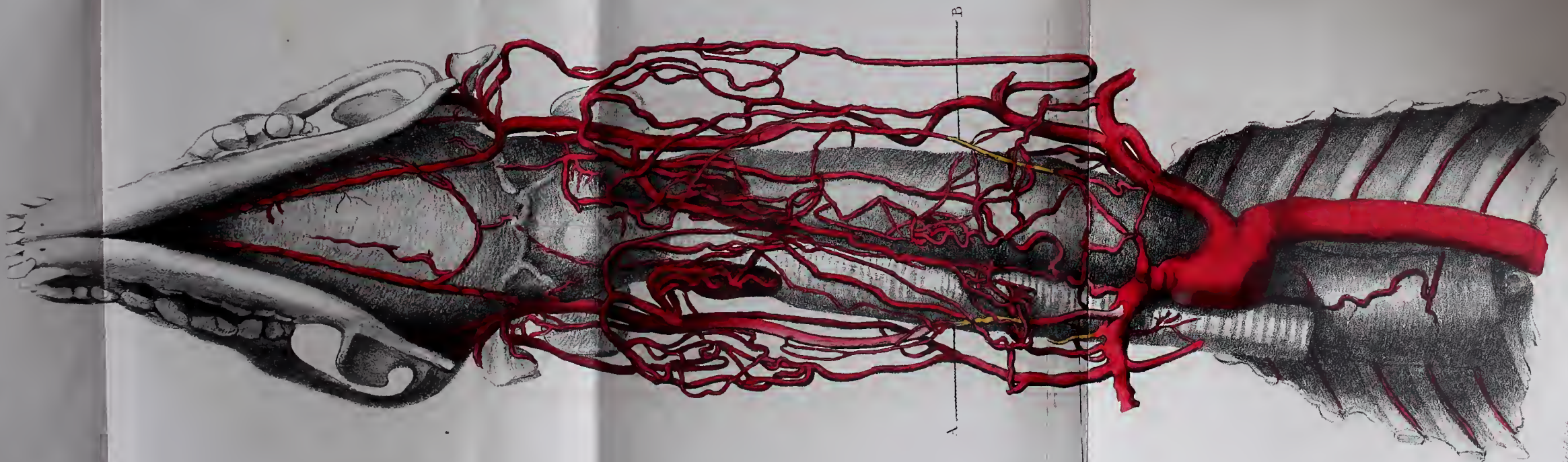
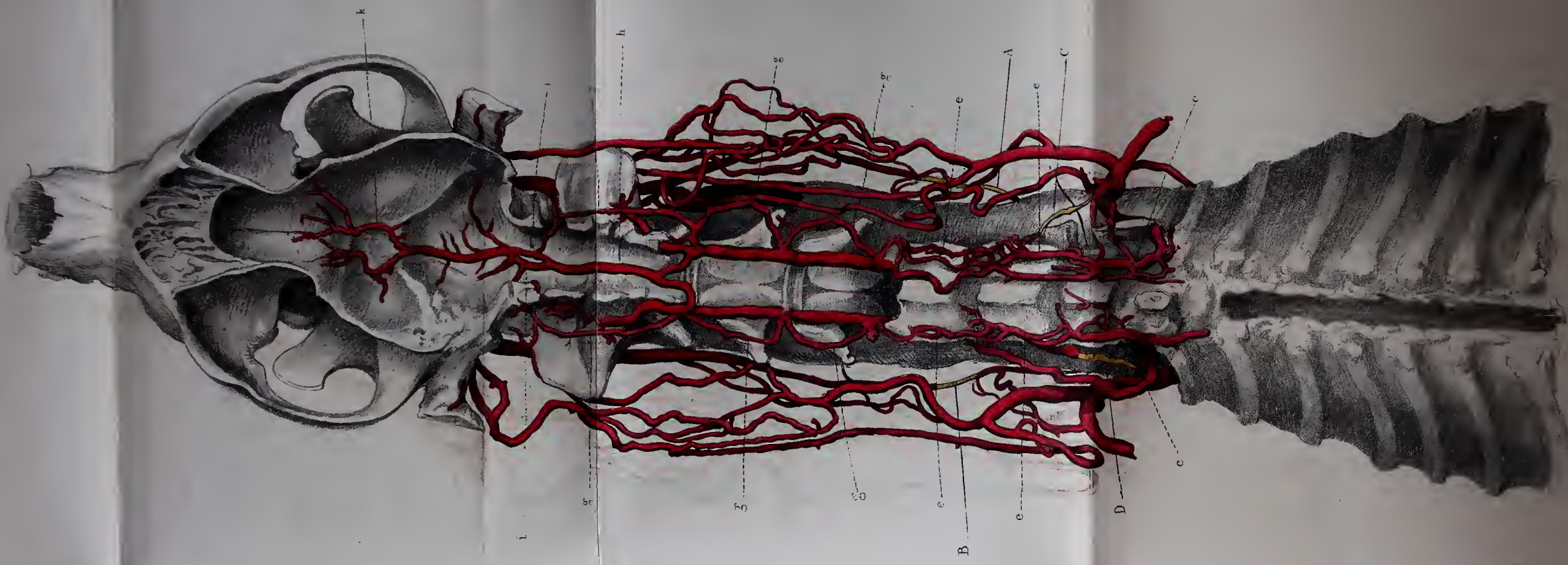


Fig. 2





PLATE, *Fig. 2.*

## BACK VIEW OF THE SAME PREPARATION.

- A B Obliterated Carotid Arteries.
- C Obliterated Vertebral Artery on the right side.
- D Obliterated Vertebral Artery on the left side, with bristles under each. Numerous anastomosing arteries from the ascending Cervical to the Carotid Arteries.
- eeeeee Anastomosing Branches from the Subclavian and Superior Intercostal to the Vertebral Artery on the outer side of the Spine.
- ggggggg Curious Loops or Festoons of Arteries of communication, running on the side of the Spine over the Transverse Processes, and entering the Vertebral Arteries opposite each intervertebral substance.
- h Basillary Artery on the second Cervical Vertebra.
- ii Basillary Artery further formed by branches from the Vertebral and Carotid Arteries.
- k Circle of Willis.



On a second occasion, I tied the left vertebral artery of a dog. I then secured the right vertebral; and after an interval of eight days I put a ligature on each carotid artery.

The animal was weakened in its fore-legs; but in other respects it suffered less than the former; and on the following days it took its food as usual.

The right carotid was obliterated; the injection passed from the aorta to the obstructed part, and above it, by an anastomosing vessel from the vertebral, and by an ascending cervical artery from the right subclavian.

The left carotid was obliterated, but filled with injection to the place of obliteration, from the aorta; and above, it was filled by an ascending cervical, an inferior laryngeal branch, and others from the vertebral.

The right vertebral artery was obliterated opposite the seventh cervical vertebra, before it entered the foramen of the sixth vertebra; but above the obliteration it was filled by an anastomosis with the superior intercostal artery: it then ascended through the canal in the sixth cervical vertebra, forming beautiful festoons and junctions with arteries passing over the vertebræ, opposite each intervertebral substance, and joining, by anastomosis, with the carotid at the first vertebra of the neck.

The left vertebral artery was obliterated at the seventh vertebra; but the artery formed anastomoses, one with the subclavian, and two with the superior intercostal.

The artery on this side formed similar but larger junctions than the right, opposite to each intervertebral substance, in festoons or loops; and thus the vertebral artery was reproduced, and filled with injection from these vessels.

The two vertebral united to form the basillary artery as usual, and joined with the internal carotids at the circle of Willis.

Where the basillary artery was first formed, anastomoses were sent to the carotid arteries on the transverse process of the first cervical vertebra.

The result of tying the carotid and vertebral arteries in the dog is such as I have described; but in the rabbit it is different, as in this animal the arrest of the blood in these four vessels is immediately fatal.

Besides the determination of this point, it was my object, in the following experiments, to ascertain the different effects which would be produced by tying separately the vertebrals and the carotids.

The size of the carotid arteries, compared with the vertebrals, is much less in some animals than in man, in proportion to the inferior development of the cerebrum; and the tractus respiratorius being supplied by the vertebrals, the current of blood in these arteries might be supposed to exercise an influence on the respiration.

#### LIGATURE PLACED ON BOTH CAROTID ARTERIES.

In the first place, I applied a ligature to the carotid artery on each side of the neck.

Little effect was produced; except, that the respiration was quickened for a few minutes, and the animal rendered dull and disinclined to eat during the day: but on the following morning it appeared lively, and ran about with its natural activity. So that it may be truly said, that these two arteries may be tied with very little change in the functions of the animal, excepting that the respiration is quickened; and this perhaps may be attributed to a greater quantity of blood being impelled through the vertebral arteries, in consequence of its interruption in the carotids.

#### LIGATURE PLACED ON BOTH VERTEBRAL ARTERIES.

I next placed a ligature around both vertebral arteries. When I had tied the first, there was some difficulty in breathing; but when I had tightened the second ligature, this difficulty was greatly increased. The respiration was at first slow, but it afterwards became quicker. The animal retained volition and sensation, but its fore legs were weakened.

At the end of two hours, its breathing was laborious; its ears dropped to the right side; its heart beat quickly; it was dull, and indisposed to move; and its fore legs were still weak.

After four hours and a half, it ran about, but with its ears fallen: its respiration was slower.

On the following day, there was a murmuring in its breathing, which was increased under excitement: its heart beat quickly and forcibly: its pupils were not dilated.

On the second day, the respiration was slow and heaving;

it had an irregular action of the heart; it was dull; and its heat was 102. In the evening, its respiration was irregular and heaving; but it moved about, and took food.

On the third day it was dull: its breathing was slow: its heart beat quickly: it ate food.

On the fourth day, it appeared heavy, and indisposed to move. The action of its heart was quick and strong: its respiration was slow, but no longer stertorous.

On the fifth day, its breathing was slow: it appeared dull and heavy: the action of the heart was still quick.

On the sixth day, the respiration was laborious and slow, being only 64, instead of between 120 and 150, the natural number of inspirations in a minute: its heart beat rapidly, and not forcibly: it was very dull, and indisposed to move: it was getting thin, but it took its food as usual.

On the seventh day the animal was found dead; and on the eighth I examined it, after injection, and found an abscess in the neck. The vertebrae had been well secured, and the brain had received injection by the carotid: the basillary and cerebellar arteries were filled from the *circulus arteriosus*. This animal's death may have been hastened by the abscess.

I have many times repeated this experiment; and it uniformly produces a marked effect upon the respiration, which it renders slow and laborious. The fore legs are weakened; and a much more severe effect is produced upon the animal than when the carotid arteries are obstructed; insomuch, that it will rarely recover from the operation.

#### THE CAROTIDS FIRST TIED, AND THEN THE VERTEBRAE.

The next step was, to ascertain the effect of arresting the blood in the vertebrae, after the carotids had been secured.

I tied the carotid arteries: the respiration and circulation became quicker: volition and sensation remained in all their activity.

In twenty-four hours, the animal appeared very lively, but its breathing was quicker than natural. After forty-eight hours, it breathed less quickly; it ran about in a lively manner; and it ate heartily.

On the third day, it was difficult to catch: on the fourth, fifth, sixth, seventh, and eighth days, it appeared to be quite in a natural and healthy state: and on the ninth I exposed the



vertebral arteries, and found them obviously enlarged. A ligature was tied upon each of these vessels. The respiration stopped immediately, and the animal appeared dead; but it afterwards made seven gasps, from convulsions of the diaphragm: its hinder extremities became also convulsed; but in a minute, all voluntary motion ceased.

On opening the abdomen and chest, it was seen that the peristaltic motion of the intestines remained; and the heart continued to act for a few minutes after apparent death.

This experiment shews how little the functions of the brain depend upon the carotids, and how much upon the vertebral arteries.

#### CAROTIDS TIED—VERTEBRALS COMPRESSED.

As tying the vertebral arteries is a difficult experiment, it occurred to me that I might compress them with my fingers, after tying the carotids, and produce the same effects.

I tied the carotid arteries. Respiration was somewhat quickened, and the heart's action increased; but no other effect was produced. In five minutes, the vertebral arteries were compressed by the thumbs, the trachea being completely excluded. Respiration almost directly stopped: convulsive struggles succeeded; the animal lost its consciousness, and appeared dead. The pressure was removed; and it recovered, with a convulsive inspiration. It laid upon its side, making violent convulsive efforts; breathed laboriously; and its heart beat rapidly.

In two hours it had recovered; but its respiration was laborious.

The vertebrals were compressed a second time. Respiration stopped: then succeeded convulsive struggles, loss of motion, and apparent death.

When let loose, its natural functions returned, with a loud inspiration, and with breathing excessively laboured.

In four hours, it was moving about, and ate some greens.

In five hours, the vertebral arteries were compressed a third time, and with the same effect.

In seven hours, it was cleaning its face with its paws.

In nine hours, the vertebral arteries were compressed for the fourth time; and with the same effect upon its respiration.

After thirteen hours, it was lively.

In twenty-four hours, the vertebral arteries were compressed for a fifth time, and the result was the same; viz. suspended respiration, convulsions, loss of motion, and consciousness. On the removal of pressure, violent and laborious respirations ensued; and, afterwards, the breathing became very quick.

After forty-eight hours, for the sixth time, the compression was applied, with the same effect.

Thus it appears, that if the carotid arteries are tied, simple compression of the vertebrales succeeds in putting an entire stop to the functions of the brain.

#### VERTEBRALS TIED—CAROTIDS COMPRESSED.

I then reversed the preceding experiment, by impeding the current of blood first in the vertebral arteries.

I placed a ligature tightly around the vertebral arteries.

The respiration became immediately laborious: its right ear fell, and the right fore-leg was partially paralyzed.

In one hour, it was indisposed to move; its respiration was slow and laborious; and its right fore-leg in a great degree recovered. Its sensation remained; but its volition was less than before the experiment: it smelt at the food offered, but would not eat it.

In three hours, green food was placed in its mouth, which it ate.

In five hours, it was running about; but its right ear remained in the same situation.

On the following day, its respiration was slow, and it appeared dull.

I pressed, with my thumbs, the carotid arteries on each side of the larynx, which was left free.

It fell upon its side; it lost all sensation and volition; and its eyes were drawn back.

Upon removing the pressure, it soon recovered.

On the second day, its respiration was quick; its ear much risen; its fore leg less paralytic: it sat up; and moved from place to place.

A second time I compressed its carotids. Its eyes were drawn back; it was convulsed; and its respiration was quick

and laborious; and it was affected in the same way as on the preceding day, but in a less degree.

On the third day, its respiration was hurried, and 150.

For the third time I compressed its carotids. It fell upon its side, and was insensible; but soon recovered, and ran about.

On the fourth day, it was dull, and its respiration was laborious: it ate some green food.

In the afternoon of this day, it became very dull, and refused the food placed before it; and on the morning of the fifth it was found dead.

I injected this animal with coarse injection: and, upon dissection, it was found that abscesses had formed around the ligatures. The vertebral arteries were fairly tied, and the carotids greatly enlarged, but they were compressed by the abscesses.

The injection had entered the cranium by the internal carotids, but not by the vertebrales; nor was there any injection in the basillary artery by the circle of Willis.

#### CAROTID AND VERTEBRAL TIED ON THE SAME SIDE.

On another occasion, I tied the carotid and vertebral arteries on the same side: the breathing became laborious, and the fore-leg was partially paralyzed. I subsequently compressed the vessels on the other side, with the usual effect of producing apparent death: but the pressure being removed, the animal recovered; and at the expiration of eighteen days it was quite well, excepting that it had a difficulty in breathing, under excitement. It was then killed and dissected. The arteries had been securely tied.

It appears, then, that the obliteration of one carotid and one vertebral, on the same side, does not produce a fatal effect.

#### VERTEBRAL AND CAROTID ARTERIES TIED AT THE SAME TIME.

In order to cut off at once the several currents of blood to the brain, I tied at once both the vertebral and carotid arteries.

The animal breathed no more; but there were thirteen or fourteen convulsive contractions of the diaphragm, and convulsions of the hinder extremities, and the animal ceased to exist.

This is a most decisive experiment; shewing the effect of the arrest of the blood in the vessels of the brain, in stopping



respiration, volition, and sensation; and the result is striking and immediate.

The same effect of interrupting the streams in the vertebrals and carotids was produced in an equally conspicuous manner, without the application of ligatures, as follows. The animal was held in a convenient position, with its neck extended, and its head thrown back. I then applied my thumbs, so as to compress, at the same time, the two vessels on each side, taking care to leave the trachea entirely free from compression. Respiration ceased in a few seconds: some struggling then took place, and the animal appeared dead. The pressure being then removed, the respiration was completely suspended; but artificial motion being given to the ribs, the animal gasped, began to breathe quickly, and recovered.

I also put a ligature around the neck, close to the sternum, so as to compress the carotid and vertebral arteries; but the trachea was excluded, by passing the ligature behind it. Although the trachea remained free, as soon as the ligature compressed the carotid and vertebral arteries, breathing ceased, and all the functions of the brain were destroyed.

Before I would venture to draw conclusions from the experiments above detailed, I was desirous of convincing myself that no injury done to the nerves could have influenced, in any material degree, effects which had been observed. I proceeded, therefore, to investigate the consequences of applying ligatures to the principal nerves of the neck.

#### LIGATURES PLACED ON THE PNEUMO-GASTRIC NERVES.

In the first place, I put a ligature on each pneumo-gastric nerve. The animal's breathing became heaving and laborious, and fell from 150 to 48 inspirations in the minute: it was likewise accompanied by a stertorous noise: the heart beat feebly, but rapidly: food was refused. These symptoms continued; and on the following morning it was found dead. The same experiment was several times repeated, and the results were nearly uniform, the animals dying at the end of from nineteen to twenty hours.

In these experiments, it was likewise observed that the blood circulating in the arteries gradually assumed the venous colour,



and that the animal heat at the same time decreased in a remarkable degree.\*

The examinations after death exhibited the lungs gorged with blood, and looking like the liver; a fluid in the pleuritic cavity; the stomach full of undigested food; and the œsophagus

\* These facts were carefully noticed in the following experiments:—

#### EXPERIMENT 1, ON THE RABBIT.

Respiration, 132 in a minute: Heat 104.

The pneumo-gastric nerve was tied on each side: the breathing became stertorous; the animal dull, and disinclined to move.

In 1 hour, respiration 48.

3 hours ..... 44.

4 ..... 56. Animal Heat  $99\frac{1}{4}$  in the anus.

8 ..... 48. ....  $93\frac{1}{4}$ .

I opened the carotid artery, and blood of a venous colour escaped. I tied the artery.

In 11 hours, respiration ..... 36. Animal heat 93.

$11\frac{1}{2}$  ..... laborious, and 30. ....  $90\frac{1}{4}$  to  $\frac{1}{2}$ .

12 ..... respiration the same. .... 89.

The rabbit died at this time, and the heat of the abdomen was  $88\frac{1}{2}$ .

#### Examination.

Lungs loaded with dark blood: water in each cavity of the pleura: food in the œsophagus: stomach loaded with food.

#### EXPERIMENT 2.

The Pneumo-gastric nerves tied.—Respiration 135 before the experiment. Animal Heat 102.

In 1 hour, respiration 48. Animal Heat 99.

3 hours ..... 39. .... 99.—(Stertor, or moaning, under excitment.)

4 ..... 33. ....  $98\frac{1}{2}$ .—(The animal dull, and disinclined to move.)

6 ..... 36. .... 96: cold to the touch.

12 ..... 36. ....  $97\frac{1}{2}$ .

14 ..... 32. ....  $95\frac{1}{2}$ .

16 ..... 28. .... 93.

$16\frac{3}{4}$  hours the animal died. Its heat 87 in the abdomen, at the time of its death.

The animal felt cold long before it died.

The gradual decrease of the animal heat, the dark blood circulating in the arteries, and the gorged state of the lungs after the application of a ligature to the par vagum, are interesting and important circumstances: and we are led to question, whether the lungs, by this operation, are deprived of a nervous or vital influence essential to the change of the blood; or whether this change is not produced in consequence of the slowness of the animal's breathing: for when the phrenic nerves have been tied, the blood also becomes dark in the arteries. In that case, however, the lungs are not found gorged with blood.

likewise distended with it, in those cases in which the animals had taken food after the ligatures had been applied.

#### LIGATURES PLACED ON THE PHRENIC NERVES.

In another rabbit, I divided the phrenic nerves one after the other, in immediate succession.

The diaphragm being then paralyzed, the animal's respiration, which was performed by the intercostal muscles, instantly became excessively laborious. The ribs were heaved violently; and a much greater effect was produced on the respiration than when the vertebral arteries, the pneumo-gastric nerve, or grand-sympathetic, were tied.

In a quarter of an hour it lay upon its side, making great efforts with its intercostal muscles; and sometimes it stopped, as if fatigued, and then again commenced. In twenty minutes it was dead. On examination, the phrenic nerves were found to be completely divided.

The heart's action, and the peristaltic motion of the bowels, were observed for a short period after apparent death.

In this experiment, respiration was rendered difficult, by obstruction to the mechanical apparatus destined to provide the necessary supply of fresh air: whereas, in the former, the difficulty arose from the failure of those processes which in health are carried on within the lungs; and may we not thence infer, that the changes of the blood are not chemical alterations merely, but dependent also upon the vital agency of the nerves and blood-vessels?

#### LIGATURES PLACED ON THE GRAND-SYMPATHETIC NERVES.

I now tied the grand-sympathetic nerve on each side. The respiration became quick and irregular; but sensation and volition were unaffected. The heart's action was very quick: there was a general trembling; but, when the animal was put down upon the ground, it ate some greens. Its respiration continued irregular, and its heart's action very quick; and after eight days it was killed. The nerves were found well tied: one had ulcerated below the ligature; the other was nearly ulcerated through; and the ligature was surrounded by suppuration.

In another rabbit, I tied these nerves; and the animal, although it is near a month ago, is still lively and active.

## LIGATURES PLACED ON THE PNEUMO-GASTRIC, PHRENIC, AND GRAND-SYMPATHETIC NERVES.

Lastly, I tied, in one rabbit, the pneumo-gastric nerve, the grand-sympathetic, and the phrenic. The respiration became laborious; the animal dull, and indisposed to move; and the heart's action feeble. The breathing continued excessively laborious for a quarter of an hour, when the animal died. Bloody fluid was found in the chest: the lungs were not much changed. In another similar experiment, the animal died in three-quarters of an hour.

We see, then, that an animal with all these nerves compressed may live from a quarter to three-quarters of an hour; that the ligatures on the pneumo-gastric kill in about twelve hours; and in the grand-sympathetic, that the animal will continue to live for a much longer period: so that pressure on these nerves, in the experiments in which the arteries were compressed by my thumbs, could not have been the cause of death.

The effect of tying the jugular veins of the rabbit is not constantly the same in all cases; as the following instances prove.

## LIGATURES PLACED ON THE JUGULAR VEINS.

In one rabbit I tied the jugular veins on each side of the neck. When it was set at liberty, it ran about, cleaned its face with its paws, and took green food.

Its respiration was reduced to 68 inspirations in a minute, which is about half the natural number. After four hours, it ran about as if nothing had happened; and eventually recovered.

When it was killed and injected, I found, on each side, three anastomosing veins passing from the anterior to the posterior part of the jugular vein, and conveying the blood from the head to the heart; but the vertebral vein had remained whole, and become enlarged; and it passed, on the fore part of the vertebræ, from the head to the space between the fourth and fifth cervical vertebræ, where it entered the vertebral canal.

In a second rabbit, I tied the jugular veins on each side of the neck, as before. The animal's respiration became slow;



but it ate green food, ran about, and was difficult to catch: but for five days after it appeared dull; its ears had dropped. On the seventh day, it was seen to be convulsed, and frequently rolled over. Its voluntary powers were lost, as well as its sensation, in a great degree. On this day it died. On examination, a clot of blood was found extravasated in the left ventricle of the brain.

Hence it follows, that apoplexy will occasionally result from an obstruction to the return of blood in the jugular veins; and this I have known to happen from enlargement of the glands in the neck of a boy.

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#### INFERENCES DRAWN FROM THE FOREGOING EXPERIMENTS.

It appears, from these experiments, that the carotid arteries are designed in these animals rather for the supply of blood to the external parts of the head than to the brain itself; whilst in proportion as the brain is more developed, the carotid artery acquires greater importance. The obstruction of it influences respiration in some degree; probably, because, under these circumstances, more blood is directed to the vertebral arteries. The internal carotid branches are proportionably less than in those animals which have a large cerebrum and are endued with higher mental faculties.

It passes tortuously to its destination, to prevent the action of the heart from influencing the brain immediately.

The rabbit quickly recovers from the operation of tying these arteries, and seems little affected by it: and in man, as well as in these animals, these vessels are obliterated without the destruction of life.

The vertebral arteries are much more important vessels, as regards the brain and its functions in these animals\*, than the carotid arteries. The nervous power is much lessened by tying them; and, in these experiments, the animal did not, in any case, survive the operation more than a fortnight; although I do not mean to say that recovery is impossible. In the dog, also, the carotids may be tied with little effect; but the vertebrales have a great influence.

\* Mr. Coleman informs me that the vessels of the horse are different; and he thinks it is designed to counteract gravitation, when the animal is feeding on grass.

The effect of the operation is, immediately to render breathing difficult and laborious, from the supply of blood to the phrenic nerves and the whole course of the tractus respiratorius of Sir Charles Bell being stopped. The animal becomes dull, and indisposed to use exertion or to take food.

Very slight injuries, after a ligature has been put upon these arteries, will destroy life; insomuch, that if they are first tied, even dissecting for the carotids, without tying them, will cause death. The best method, in such experiments, is to tie the vertebrae last.

On account of the importance of these vessels, they are securely defended by bone in the greater part of their course; and it is only below the sixth cervical vertebra that they are accessible. If they were exposed to pressure, death would often be suddenly produced.

These arteries are tortuous, to prevent too sudden a rush of blood to the head; and they pass through foramina of bones, which prevents any great increase of their size; although they become somewhat larger than before, when the carotid arteries are tied, and *vice versâ*.

Thirdly, compression of the carotid and of the vertebral arteries at the same moment, in the rabbit, destroys the nervous functions immediately. This is effected by the application of the thumbs to both sides of the neck, the trachea remaining quite free from pressure; when respiration entirely ceases, with the exception of a few convulsive gasps.

The same fact is evinced in a clearer and more satisfactory manner, by the application of ligatures on the four vessels, all being tightened at the same instant; when stoppage of respiration, and death, immediately occur.

When the dog is the subject of this experiment, it loses its volition and sensation, and appears as if it were intoxicated; but the anastomosing vessels gradually restore the circulation, by means of the other branches of the subclavian artery at the back and sides of the neck.

But, notwithstanding the decisive nature of the last experiment, conceiving that it might be possible that the pressure upon the nerves of the neck might have an influence in killing the animal suddenly, I made the experiments which I have detailed.

I first tied the pneumo-gastric nerves; and found that the

animal lived about twelve hours, although it died on the instant when the carotid and vertebral arteries were tied: the lungs were also loaded with blood\*, and twice as heavy as the healthy lung: it appears, therefore, that the change of the blood is either directly or indirectly under the influence of the par vagum.

In this experiment it is also to be observed, as a point of much importance, that the blood in the carotid arteries is found of a venous character, and dark blood circulates in the animal for some time before it dies, the blood being less arterial as the time elapses from the application of the ligature: yet the heart continues to beat; for when the artery is opened, the blood flows *per saltum*.

The blood also flows of a dark colour when the carotid is opened after the phrenic has been tied; but the lungs are not in that case found loaded with blood, but possessing their ordinary weight and appearance.

In this experiment, there was also a remarkable diminution of animal heat. Is this to be attributed to a cessation of that pulmonary process accompanied by the evolution of heat wherein venous is converted into arterial blood? or does it arise from a want of that supply of arterial blood to the nerves from which they derive a capability of evolving caloric? or shall we not approach still nearer to the truth, in supposing that both these causes of a high temperature are suspended at the same time; and that there is, consequently, a double reason for the gradual departure of the animal heat observed in this experiment?

The œsophagus contained food, in some instances in which the animal had eaten after the experiment, from its muscles being paralyzed; and the stomach was full, from the arrest of the digestive function.

This nerve, then, is most important; 1st, in assisting in the support of the function of the lungs, by contributing to the changing of the venous into arterial blood: 2dly, in being necessary to the act of swallowing: 3dly, in being very essential to the digestive process†.

\* Sir Benjamin Brodie has mentioned this state of the lungs.

† A ligature on one nerve only does not destroy.



The pair of nerves upon which I next applied ligatures were the phrenics. As soon as these were tied, the most determined asthma was produced; breathing proceeded by means of the intercostal muscles; and the chest was elevated to the utmost by them; and in expiration, the chest was as remarkably drawn in. The animals did not live an hour; but they did not die suddenly, as they do from pressure on the carotid and vertebral arteries. The lungs appeared healthy; but the chest contained more than its natural exhalation.

When the grand-sympathetic was tied, little effect was produced: the animal's heart appeared to beat more quickly and feebly than usual; but of this circumstance I cannot be positively certain, on account of the natural quickness of its action. The animal was kept seven days; and one nerve was ulcerated through, and the other nearly so, at the situation of the ligatures. The suppurative process was extensively set up around the ligatures. No particular alteration of any organ was observed, on examination\*. Another animal still lives, in which the sympathetic was tied nearly a month ago.

Lastly, I tied all three nerves on each side the pneumogastric, phrenic, and grand-sympathetic; and the animal lived little more than a quarter of an hour, and died of dyspnœa.

The sudden death, then, that takes place from pressure at the sides of the neck must not be attributed to an injury to the nerves, but it is owing to the impediment to the due supply of blood to the grand centre of nervous influence.

\* See Swan on the division of this nerve.



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## APPENDIX

TO EXPERIMENTS ON TYING THE ARTERIES AND NERVES IN THE NECK,  
BY SIR ASTLEY COOPER, BART.

THE following Experiments are added to those which have been already detailed (see Note, p. 15), for the purpose of shewing that the gradual decrease of animal heat, from the time of applying ligatures to the pneumo-gastric nerves, does not invariably occur, but is liable to rare, though striking exceptions.

## THE PNEUMO-GASTRIC NERVES TIED IN THE RABBIT.

## EXPERIMENT 3.

Before the experiment, respiration	33.	Animal Heat	104.
After $\frac{1}{2}$ an hour	56.		102 $\frac{1}{2}$ .
2 hours	64.		93.
4 .....	52.		86 $\frac{1}{2}$ .
6 .....	ceased		80 $\frac{1}{2}$ .

## EXPERIMENT 4.

Before the experiment, respiration	128.	Animal Heat	104.
After .....	52.		102 $\frac{1}{2}$ .
2 hours	48.		101 $\frac{1}{2}$ .
4 .....	52.		102 $\frac{1}{2}$ .
6 .....	60.		104 $\frac{1}{2}$ .
8 .....	52.		95.
8 $\frac{3}{4}$ .....	ceased		90.

## EXPERIMENT 5.

Before the experiment, respiration	124.	Animal Heat	104.
After .....	76.		102 $\frac{1}{2}$ .
2 hours	80.		102 $\frac{1}{2}$ .
4 .....	52.		102 $\frac{1}{2}$ .
6 .....	60.		101.
8 .....	56.		95.
10 .....	48.		88 $\frac{1}{2}$ .
10 $\frac{1}{2}$ .....	ceased		86.

## EXPERIMENT 6.

Before the experiment, respiration	96.	Animal Heat	104.
After .....	56.		102 $\frac{1}{2}$ .
2 hours	68.		102 $\frac{1}{2}$ .
4 .....	52.		102 $\frac{1}{2}$ .
6 .....	72.		104.
8 .....	52.		105 $\frac{1}{2}$ .
10 .....	48.		102.
10 $\frac{3}{4}$ .....	ceased		98.

The last experiment exhibits an increased temperature until the last moment; a circumstance which I have before observed, but which is not easily explained. The animal was much convulsed; which was not the case with the others.

*N.B.* The respiration of these animals is easily rendered quick, by excitement: it is quicker also in the young and weak animal. But for these circumstances allowance was made in the experiments.

[ *This subject will be continued.* ]



















